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Plant Pathology

A record of current work on plant diseases and pests

VOLUME 1, No. 1
March, 1952

Published for the Ministry of Agriculture and Fisheries
Plant Pathology Laboratory, Harpenden,
by Her Majesty's Stationery Office

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INTRODUCTION

'PLANT PATHOLOGY'

THE SCIENCE OF PLANT PATHOLOGY *is concerned with all pathological conditions in plants and plant produce, whatever causal agent is involved. It therefore provides common ground for the mycologist, entomologist, virus worker, helminthologist, bacteriologist, nutrition or soil chemist, meteorologist, and plant physiologist, each specializing along his own lines, but collaborating closely with workers in cognate branches. The periodical* PLANT PATHOLOGY, *like the science from which it takes its name, will be wide in its scope. It will contain original contributions on plant diseases caused by fungi, bacteria, viruses and eelworms ; on plant pests, including those of stored products ; on damage by rodents and birds ; and on nutritional and physiological disorders. It is intended primarily for the prompt publication of information on the incidence, distribution, recognition and control of plant diseases and pests in Britain. It will record survey work, including estimates of crop losses, and contain much matter of topical interest on preliminary experiments and their provisional interpretation, on forecasts, and on precautionary measures.*

W. C. Moore

Plant Pathology Laboratory,
Harpenden, Herts

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TRIALS OF SUBSTITUTES FOR SULPHURIC ACID FOR POTATO HAULM KILLING

Contribution from the Conferences of Crop Husbandry Officers and Plant Pathologists, National Agricultural Advisory Service, compiled by E. C. Large of the Plant Pathology Laboratory, Harpenden

During 1951, co-operative trials were carried out to a uniform plan at eleven centres in England and Wales to compare the efficacy of sulphuric acid, sodium chlorate, sodium arsenite, a tar-acid emulsion (TAC 49) and a tar-oil fraction (TOF 54) for the destruction of potato haulm. The materials for trial were selected, in consultation with the Agricultural Research Council and the Department of Scientific and Industrial Research, to include the principal substances available, or potentially available, at an economic cost both for use in place of sulphuric acid during a world shortage of sulphur, and also for use in ordinary spraying machines without special acid-proof equipment.

The scheme of trials provided for the testing of each of the five materials, at rates of application as listed below, on a single one-acre plot at each centre ; additional plots were used for the comparative testing of other treatments, including mechanical haulm destruction where this could be arranged. Most of the spraying was carried out by contractors, with the machines used by them for contract work. The subject matter of the trials falls into two parts. The first—a comparison of the direct effect of the several treatments in killing potato haulm, under varying local conditions—is dealt with in the present article ; the second part—a study of the effect of such haulm killing on the amount of blight in the tubers (in relation to the amount of blight on the haulm when the haulm killing was done, and also to the conditions at the time of lifting)—will be published in a subsequent issue of this journal.

MATERIALS AND RATES OF APPLICATION

Sulphuric Acid. BOV 77 per cent. H_2SO_4. Applied by high-volume sprayer at 15 gal. in 85 gal. water per acre ; or by low-volume sprayer at 20 gal. per acre, without dilution. Cost* with acid at, say, £10 6*s.* per ton (132 gal.) £1 3*s.* 5*d.* (high-volume) or £1 11*s.* 3*d.* (low-volume), per acre.

Tar Oil Fraction. TOF 54. A fluid coal-tar oil containing 25 per cent. or over of phenols, of which 90 per cent. distil within the range 230–300° C. Supplied by Scottish Tar Distillers Ltd., Falkirk. Applied without dilution at 25 gal. per acre by low-volume sprayer. Cost,* at 1*s.* 4*d.* per gal., £1 13*s.* 4*d.* per acre.

Tar Acid Emulsion. TAC 49. The active materials in TOF 54, extracted from the oil and emulsified for use after dilution in water. Applied by high-volume sprayer at 10 gal. in 90 gal. water per acre. Cost,* at 3*s.* 5*d.* per gal., £1 14*s.* 2*d.* per acre.

Sodium Arsenite. A liquid preparation, containing 98 per cent. As_2O_3 wt./vol. Applied at 1 gal. in 99 gal. water per acre. Cost,* at £1 7*s.* 6*d.* per gallon jar, £1 7*s.* 6*d.* per acre.

Sodium Chlorate. 99 per cent. $NaClO_3$. Applied by high-volume sprayer at 15 lb. in 100 gal. water per acre. Cost,* at £6–8 per cwt., 16*s.* to £1 1*s.* 4*d.* per acre.

* Costs of materials per acre are indicative only, and are based on prices current in 1951.

POTATO HAULM KILLING TRIALS

CONDITIONS OF TRIAL AND RESULTS AT EACH CENTRE

At all the 11 centres, assessments of the percentage kill of stems and leaves were made for each treatment at 1, 5, and 14 days after application. The assessments after 1 day are indicated in the section dealing with the mode of action of the materials. The critical comparative assessments at 5 and 14 days, for all centres, are assembled in Table 1.

TABLE 1

PERCENTAGE KILL OF LEAVES AND STEMS AT 5 AND 14 DAYS AFTER APPLICATION

"90 : 50" represents a 90 per cent. kill of leaves and 50 per cent. kill of stems. Upper figures give assessments at 5 days; lower figures, at 14 days.

Centre	*Sulphuric acid*	*TOF 54*	*Sodium arsenite*	*TAC 49*	*Sodium chlorate*	*Unsprayed control*
Cumberland ..	100 : 90 100 : 100	—	95 : 50 100 : 90	60 : 15 85 : 50	100 : 30 100 : 60	30 : 0 50 : 5
Yorkshire ..	100 : 90 100 : 100	95 : 60 100 : 90	90 : 50 100 : 85	85 : 45 99 : 75	85 : 45 99 : 75	50 : 5 80 : 30
Monmouth ..	—	80 : 10 100 : 100	—	90 : 70 100 : 100	70 : 20 100 : 98	80 : 10 100 : 25
Worcester A. ..	98 : 60 100 : 99	90 : 15 90 : 30	95 : 15 100 : 98	80 : 10 99 : 90	90 : 5 100 : 95	5 : 0 60 : 5
Worcester B. ..	—	80 : 15 90 : 70	95 : 15 100 : 80	90 : 15 99 : 80	90 : 5 99 : 30	15 : 0 70 : 5
Lincoln	— 99 : 60*	50 : 5 90 : 50	60 : 5 99 : 50	40 : 5 97 : 30	30 : 5 80 : 10	0 : 0 30 : 2
Isle of Ely ..	100 : 80 100 : 100	95 : 75 100 : 99	95 : 40 100 : 95	80 : 60 100 : 95	45 : 20 98 : 70	35 : 20 80 : 40
Hampshire ..	100 : 95 100 : 99	100 : 85 100 : 98	100 : 85 100 : 98	100 : 50 100 : 90	100 : 20 100 : 85	100 : 5 100 : 85
Kent	100 : 75 100 : 100	90 : 50 100 : 100	90 : 75 100 : 100	90 : 25 100 : 90	75 : 10 100 : 50	75 : 10 75 : 25
Wiltshire	100 : 95 100 : 100	100 : 40 100 : 95	100 : 85 100 : 100	100 : 60 100 : 98	100 : 10 100 : 75	90 : 0 100 : 75
Devon	100 : 65 100 : 95	90 : 50 100 : 85	85 : 10 100 : 90	35 : 10 100 : 80	75 : 15 100 : 80	50 : 0 95 : 5
Rothamsted ..	95 : 50 98 : 80	80 : 40 98 : 65	90 : 40 100 : 80	50 : 15 80 : 50	80 : 20 95 : 70	5 : 0 60 : 15

* See notes in text.

Cumberland. Redskin, of very vigorous growth, burnt off on September 17, when about one-third of the leaves had been killed by blight, and the stems were still green. There was dry weather for five days after spraying. Trial centre: Wragmire Moss, near Carlisle. Collaborators: W. H. Barker, C. D. Price, and H. E. Croxall.

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Yorkshire. Majestic, of vigorous growth, burnt off on September 18, when the bottom leaves were just yellowing, and blight on the haulm was at 25 per cent. The haulm was dry when sprayed, and no rain followed within 48 hours. Sulphuric acid was applied by low-volume sprayer at 20 gal. per acre. Sodium arsenite was used at double the recommended strength, i.e., at 2 gal. in 98 gal. water per acre. Supplementary treatments :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium chlorate. 15 lb. in 25 gal. water per acre	95 : 40	100 : 80
Sodium arsenite. 2 gal. in 23 gal. water per acre	95 : 50	100 : 90

Trial centre : The Horticultural Experimental Station, Cawood, Selby. Collaborators : W. W. Gatenby, A. Beaumont and I. F. Storey.

Monmouth. Majestic, impoverished and sprawling, burnt off on September 14 and 17, when most of the leaves had been killed by blight (75 per cent.) but most of the stems were still green. There was heavy rain 14 hours after spraying with TOF 54. There was some unevenness of spraying owing to roughness of the ground. Sulphuric acid and sodium arsenite were omitted from this trial. Trial centre : Horticultural Experimental Station, Cleppa Park. Collaborators : A. J. Davies, J. Rees and B. K. Randall.

Worcester A. Majestic, dense and sprawling, burnt off on September 5, when yellowing just beginning and blight at 5 per cent. There was slight rain within 12 hours of spraying, and heavy rain 30 hours after. Sulphuric acid was used at 12½ gal. in 80 gal. water per acre. TOF 54 was applied two days after the other treatments and therefore escaped rain on the night of September 6. Supplementary treatments :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium chlorate. 25 lb. in 100 gal. water per acre	90 : 5	100 : 99
TOF 54. 50 gal. per acre	95 : 40	100 : 98

Worcester B. Arran Peak, dense and sprawling, burnt off on September 5, when yellowing was just beginning, and blight at 15 per cent. Trial centre (for both A and B) : Broadheath Common, Worcester. Collaborators : D. H. Robinson, N. C. Preston, C. T. Carter, W. Patterson and W. R. Rosser.

Lincoln. Gladstone, of vigorous growth, burnt off on September 7, when mostly quite green, with blight only just starting (0·1 per cent.). There was no rain within 24 hours of spraying. Blocking of nozzles, when spraying with acid, necessitated repeat of this treatment on September 12. Assessment of acid treatment given in Table 1 was at 9 days. Poor kill of stems with other treatments at this centre was partly a variety effect. TOF 54, sprayed on Arran Peak at the same time as on Gladstone, gave 99 : 70 kill after 14 days. Supplementary treatments :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium arsenite. 1 gal. in 19 gal. water per acre	95 : 25	99 : 85
TOF 54. 15 gal. per acre	50 : 5	90 : 35

Trial centre : Branston Island, near Lincoln. Collaborators : S. S. J. Travers, H. H. Stirrup, T. R. W. Powell, J. B. Page, P. Twiss, E. Lester and E. R. Wallace.

Isle of Ely. King Edward, upright and moderately vigorous, burnt off on September 14, when about one-third of the foliage had yellowed off, and blight was still at less than 0·1 per cent. as the result of four dustings. The weather was dry and rather windy on the day of application ; there was heavy rain on the day following. Sulphuric acid was used at 18–20 gal. per acre, TOF 54 at 29 gal. per acre. Trial centre : Plantation Farm, Littleport (Henry Thompson, Ltd.). Collaborators : C. V. Dadd, W. A. R. Dillon Weston, P. Y. Hobson and Miss E. R. Schofield.

Hampshire. Majestic, of moderate vigour, burnt off on September 17, when almost all the leaves had already been killed by blight (85 per cent.). There was no rain within two days of spraying. The trial was practically confined to the killing of stems. Trial centre : Northwood Farm, Hayling Island (Mr. H. Brown). Collaborators : R. G. Hughes, W. Buddin, G. W. Woodrow and E. T. Roberts.

Kent. Majestic, of moderate vigour, burnt off on September 10, when yellowing, and with about 75 per cent. of the leaves already killed by blight. There was a light shower six hours after spraying, and considerable rain 40 hours after. Supplementary treatments :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium arsenite. 1 gal. in 24 gal. water per acre	90 : 75	100 : 100
TOF 54. 50 gal. per acre	100 : 75	100 : 100

Trial centre : Wye College Farm. Collaborators : H. H. Glasscock, J. N. Sharrock, J. J. Walker and D. Wyllie.

Wiltshire. Majestic, of moderately vigorous growth, burnt off on September 11, when 75 per cent. of the foliage had already been killed by blight but the stems were still green. There was no measurable rain within 48 hours of spraying. Trial centre : Bowden Park Farm, Lacock (Paget Bros.). Collaborators : W. Q. Connold, L. Ogilvie, H. T. Horsman, K. W. Silverstone, P. F. Keevil and A. G. Robertson.

Devon. Arran Banner, of moderate vigour, burnt off on September 4, when about one-third of the leaves had been killed by blight and potash deficiency (blight 25 per cent.) but stems were fully green. There was no rain within 24 hours of spraying, but some during the following two days. Supplementary treatment :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium arsenite. 1 gal. in 25 gal. water per acre	95 : 10	100 : 90

Trial centre : Beadon Farm, Bovey Tracey (Mr. F. Hambling). Collaborators: G. E. Furse, G. H. Brenchley, K. M. Pearman, D. G. Baglow, W. Campbell, R. Hawken, H. T. Horsman and A. D. Beale.

Rothamsted. Majestic, of moderate vigour, burnt off on September 26, when prostrate, but fully green apart from a few yellowing plants and blight about

10 per cent. There was heavy rain on the day after spraying. Supplementary treatments :

Treatment	*Leaf : Stem kill at* 5 *days*	14 *days*
Sodium arsenite. 1 gal. in 25 gal. water per acre	60 : 20	95 : 60
Sulphuric Acid at 15 gal. in 85 gal. water per acre after flattening of the haulm with a Cambridge roll	80 : 60	100 : 90

Trial centre : Rothamsted Experimental Farm (Mr. J. R. Moffat). Collaborators : J. M. Hirst, E. C. Large and F. Joan Moore.

RELATIVE EFFICIENCY AND MODE OF ACTION OF THE MATERIALS

As Table 1 shows, there was some variation from centre to centre in the order of merit of the several materials in respect of the rapidity with which they killed the leaves and stems. The efficiency of the spraying machine used, and the correctness or otherwise of its setting, affected the performance of the materials, but over the centres as a whole the order was as follows :

Sulphuric acid, high or low volume	1
TOF 54, low volume	2
Sodium arsenite, high volume	
TAC 49, high volume	3
Sodium chlorate, high volume	

Sulphuric Acid. Whether applied at high or at low volume, sulphuric acid gave an almost immediate kill of the leaves, which were generally hanging limp and partly bleached before the end of the day on which the spraying was done. The kill of the stems, however, was by no means immediate, and it was common to see about half of the stem area still green five days after the application.

Contractors were accustomed to the use of acid, and raised no objection to it. Protective clothing and acid-proof machines were required, however, and even the acid drift, two hundred yards to leeward of the sprayer, sometimes caused smarting and reddening of the unprotected skin.

Tar Oil Fraction. TOF 54. This oil spray spread well over the leaves, most of which appeared dark and oil-soaked within an hour of application. Not all the sprayers worked at a sufficiently high pressure to give a good cover with as little as 25 gallons per acre, and it was chiefly for this reason that the leaf-kill was slightly inferior to that with acid after five days. The killing of the stems was dependent upon the power of the sprayer to drive the material in among them. It was found that the spraying nozzles would deliver about 20 per cent. more of TOF 54 than of water when the pressure was kept constant. Attention to the choice of the best nozzles for TOF 54 was therefore indicated, and it was found at several centres that, with nozzles as for acid, a better kill of the stems could be obtained, if desired, by increasing the amount applied. Applications up to, say, 35 gal. per acre might be recommended for very dense or vigorous haulm. When efficiently applied, however, the material at 25 gal. per acre, gave almost as good an overall kill as did acid, and the condition of the stems was equally satisfactory for lifting. The superficial oily film on the foliage and soil generally disappeared within a few days, and the dying haulm turned a dark biscuit colour. The typical appearance of the haulm five days after spraying with TOF 54, in comparison with that after spraying with acid, is shown in Plate II.

TOF 54 contained some tarry material difficult to remove from the sprayer. Where the machine was clean to start with, however, there was no blockage of the nozzles or filters. The material caused some smarting when left in contact with the naked skin, and had a persistent, though not unpleasant, phenolic odour.

Sodium Arsenite. There was no immediate effect of spraying ; browning of the leaves began within two days of the application, and this was often followed by an upward curling of the leaflets. Most of the leaves were hanging, bunched and brown, on the stems, five days after application. The stems died slowly, but were nearly completely dead within 14 days.

No difficulty was found in applying the material, but some contractors expressed uneasiness in having to handle arsenic, especially in its concentrated liquid form, and special precautions had to be taken in the disposal of material left in the sprayer after use.

Low-volume spraying with sodium arsenite was tried at the Yorkshire, Lincoln, Kent, Devon and Rothamsted centres. At three of these centres, the low-volume spraying had somewhat better effect than the high-volume, at one the effects were equal, and at another, Rothamsted, the effect was not so good.

Tar Acid Emulsion TAC 49. The action of this emulsion was similar to that of the oil spray TOF 54, but much more patchy. The foliage appeared partly oil-soaked and partly green, within a few hours of application. Death of the oil-soaked portion proceeded as with TOF 54, but the cover and spread of the material on both leaves and stems was not so good. At most centres, the material gave a fair practical kill within 14 days, but on the whole, the results were disappointing as compared with those obtained in trials of similar emulsions in 1944 and 1945 (Wilson *et al.*, 1947*).

Reports of gumming of filters, and of separation of the material in the sprayer, were received from two centres, and it was noted that, on standing, there was some settlement of the material into two layers. Some fault in the emulsification may have been responsible for the relatively poor field performance. The material caused some smarting when left for any considerable time in contact with the naked skin.

Sodium Chlorate. The action of sodium chlorate on the haulm was similar to that of sodium arsenite, but slower. Browning of the leaves began within two or three days of spraying ; the leaflets often curled upwards as the browning extended, and the stems were, in general, still partly green after 14 days. Experience at some centres suggested that the stem kill was best where a considerable expanse of leaves was still left on the stems at the time of application. A trial with sodium chlorate at low-volume, at the Yorkshire centre, gave results similar to those with high-volume application.

MECHANICAL HAULM DESTRUCTION

Preliminary trials of mechanical haulm destruction were a special feature of the work at the Isle of Ely Centre (C. V. Dadd), and trials with one or other of the following four types of machine were included at nearly all centres.

* WILSON, A. R., BOYD, A. E. W., MITCHELL, J. G., and GREAVES, W. S. (1947), Potato Haulm Destruction with Special Reference to the Use of Tar Acid Compounds. *Ann. appl. Biol.*, **34**, 1–33.

Horizontal haulm cutters, having two horizontal cutting discs mounted on the front of the tractor. (The Bettinson Haulm Cutter. P. B. Bettinson & Co. Ltd., Holbeach, Lincs)

Rotary-cultivator cutters, having vertical discs with inclined blades on a horizontal spindle mounted at the rear of the tractor. (Howard Potato Haulm Pulverizer. Rotary Hoes Ltd., East Horndon, Essex.)

Rotary rubber flails, having solid rubber flails attached to a horizontal shaft driven from the power take-off, the machine being trailed behind the tractor. (The Rotoflail, Pest Control Ltd., Harston, Cambs)

Rotary hammer pulverizers, having loose-hanging, fast-revolving steel hammers mounted on a horizontal shaft in a trailer unit, and driven from the tractor power take-off. (A prototype machine. H. Leverton & Co. Ltd., Spalding, Lincs)

The four types of machine differed essentially in their modes of action, but all effectively cut or pulverized the greater part of the haulm. The horizontal cutters, when properly adjusted, cut the upright stems close to the tops of the drills, but inevitably missed a few of the prostrate side stems which remained sprawling over the furrows. The rotary cultivator type of cutter generally gave a successful cut of both the upright and the sprawling stems, having cutters operating at the sides of the drills, but both the horizontal and the vertical cutters generally left short, green stumps of stem standing, and deposited the debris of cut stems in the furrows. These two types of machine, with the appearance of the drills after the cutting, are illustrated in Plate III.

The rotary hammer pulverizer, tried at the Lincoln centre, gave a thorough disintegration of most of the haulm, but left longish stumps of bruised stem still standing, with masses of the debris in the furrows. The rotary rubber flail, tried on upright King Edward on fen soil at the Isle of Ely centre, also thoroughly disintegrated most of the haulm, but left relatively tall, bruised skeletons of the main stems standing. The pulverized debris was scattered more or less uniformly over the drills, and much of it was buried under a thin layer of scoured soil.

A few tubers near the surface were exposed or dislodged here and there by the action of all the machines, but with cutting elements properly adjusted to suit the drills, this effect was slight.

Under the moist and dull conditions prevailing over the period of the trials in 1951, the debris of the haulm, after mechanical cutting, dried up very slowly ; and where blight was present, the fungus was generally found to be sporing actively on the masses of cut leaves and stems in the furrows for at least a fortnight after the operation. The stumps or bruised skeletons of the main stems that were left standing tended to die down fairly quickly, but where blight was present on them, sporing continued until their death.

The operation of mechanical haulm cutting was slower than spraying. The machines, cutting two rows at a time, had to operate with a tractor speed of 3½ miles per hour, in order to clear two acres per hour, and often a cleaner cut was obtained at considerably lower speeds. Large contract sprayers dealt with 16 rows at a time at about the same tractor speed, but against this, time was needed for filling the sprayer, and not infrequently it could work only in one direction—against the wind.

Potato Haulm Killing Trials

As a means of clearing the drills in preparation for lifting, as apart from blight control, mechanical haulm destruction appeared very attractive. Some types of machine were relatively inexpensive, and the work could be done easily by the farmer himself, at about half the cost of spraying with acid.

Control of Weeds and Facilitation of Lifting

Careful observations on the control of weeds by the several chemical treatments were made at Rothamsted and at a number of other centres. In general, the effect of the treatments on weed control was found to be of the same order as that of their kill of potato haulm. Mechanical haulm destruction cleared the taller weeds and smaller weeds at the tops of the drills, but, naturally, left much of the smaller weeds at the bottoms of the furrows more or less untouched. No objection was raised to any of the treatments on the score that they left the haulm in a condition likely to obstruct lifting. Efficiency of clearance for lifting was essentially the same as efficiency of stem kill as shown in Table 1.

Grateful acknowledgment is made to all those farmers who put crops at the disposal of the National Agricultural Advisory Service, for the purpose of these trials, and to manufacturers and agents of mechanical haulm killers for their co-operation. The trials were planned in consultation with Mr. G. Samuel and Dr. A. R. Wilson of the Agricultural Research Council, and co-ordinated at the Ministry's Plant Pathology Laboratory at Harpenden.

THE IDENTIFICATION OF APHIDS OF ECONOMIC IMPORTANCE

by H. L. G. Stroyan

Department of Zoology, University of Cambridge

This series of short generic descriptions is designed to meet the needs of economic entomologists for a compact account of the most important genera of British aphids of economic importance. Only 16 selected genera will be described, and the diagnoses should not be expected to prove valid if their use is extended to aphids other than those normally met with in economic and advisory work. Many good taxonomic studies of aphids as a whole are now available, and brief references to this literature are given with the diagnoses.

Unless otherwise stated, references to Theobald, Hille Ris Lambers and Börner are to Theobald's *The Plantlice or Aphididae of Great Britain* (1926, 1927, 1929), Hille Ris Lambers' contributions to a *Monograph of the Aphididae of Europe* (1938, 1939, 1947, 1949), and Börner's contribution to Vol. 5 of Sorauer's *Handbuch der Pflanzenkrankheiten* (1932).

The magnification of the text figures is variable, but those of head, siphunculi and cauda of all genera are of comparable scale *within* the genera, thus giving a measure of the ratio of siphuncular and caudal lengths to the width of the head.

ACYRTHOSIPHON Mordvilko

The species of this genus were placed by Theobald (1, 55) in *Macrosiphum* Passerini. Earlier, Buckton had included them in *Siphonophora* Koch (*A Monograph of British Aphides*, Vol. 1). The genotype, and most important species economically, *A. pisum* (Harris), is also widely known in economic and systematic literature as *Macrosiphum pisi* (Kalt.), *Illinoia pisi* (Kalt.) and *Acyrthosiphon onobrych(id)is* (B. de F.).

GENERIC CHARACTERS

Large or medium-sized pale green to yellowish or salmon pink aphids. There are three subgenera, of which only the typical one is dealt with here. Head in apterae with well-marked lateral frontal prominences, smooth or only very slightly rough, and with their inner margins divergent ; median frontal prominence absent or very small. Antennae rather long and thin, with 0–12 rhinaria on joint III ; typically with not more than five in the economic species. Processus terminalis from about three to six times as long as basal part of joint VI. Dorsum in both apterae and alatae entirely pale, without a distinct sclerotic pattern (with one exception). Siphunculi rather or very thin, fairly to very long, cylindrical or slightly tapering, a little rough, with a variably developed flange. Cauda elongate, rather acute at apex, not constricted at base. Closely related morphologically is *Microlophium* Mordvilko, living only on *Urtica* spp., on which *Acyrthosiphon* does not occur. The former genus forms a link between *Acyrthosiphon* on the one hand and *Aulacorthum* Mordvilko on the other.

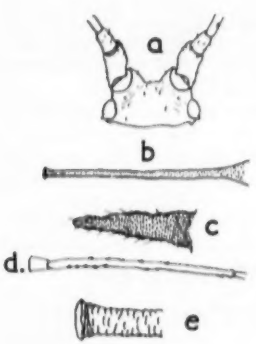


Fig. 1. *Acyrthosiphon pisum* (Harris), apt. v. ♀
a. Head. b. Siphunculus. c. Cauda. d. 3rd ant. joint. e. Apex of siphunculus, further enlarged.

ECONOMY

The genus is biologically associated with plants mainly belonging to the Papilionaceae, Euphorbiaceae and Geraniaceae, and is thus rather heterogeneous. The only major pest species in Britain is the genotype *A. pisum*. This lives on a large number of herbaceous Papilionaceae, and, perhaps, consists of a number of biological races. Morphologically, it is distinguished by the large size and very long thin siphunculi, which over much of their length are hardly thicker than the third antennal joint. It is a pest of peas, clover and lucerne in particular, but can also live on beans, and various wild hosts such as *Ononis* can probably act as reservoirs of infestation.

Other species which may be a nuisance occasionally are *A. malvae* (Mosley), a smaller pale-green to yellowish species attacking *Pelargonium* in hothouses (subsp. *malvae s.s.*) and strawberries (subsp. *rogersii* Theob.), and *A. primulae* (Theob.), attacking *Primula* spp. mainly of the *Obconica* group, a pale yellowish species in which the alatae have a strong black sclerotic pattern on the abdomen, unlike all the other species.

LITERATURE : Hille Ris Lambers (*Temminckia* 7, 211).

AMPHOROPHORA Buckton

Of the species placed by Theobald (**1**, 176) in *Amphorophora*, only *A. rubi* (Kalt.) and *A. ampullata* Buckton (the genotype) remain there now, with *A. fragariella* Theob. and *A. laingi* Mason sunk as synonyms repectively of the former two. The rest are now placed in a variety of other genera and, where necessary, will be noticed under those genera. Börner (**5**, 624) uses a most confusing conception of the genus.

GENERIC CHARACTERS

Rather large green or reddish aphids. There are two subgenera, of which only *Amphorophora s.s.* is important here. Body elongate or oval, with long legs and antennae, the latter longer than body. The inner margins of the lateral frontal prominences are nearly straight and distinctly divergent. They are at most very slightly roughened with spinules. Antennae with fairly numerous rhinaria on joint III in apterae, mostly on basal half ; alatae with rhinaria only on III in British species. Abdomen with dorsum smooth, without a sclerotic pattern in apterae, in alatae sometimes with pale brown marginal sclerites and rarely very pale segmental bars. Siphunculi long, distinctly though usually only slightly swollen on apical half, with a clearly marked apical flange, and without regular reticulations before apex. Cauda not very elongate, somewhat blunt at apex.

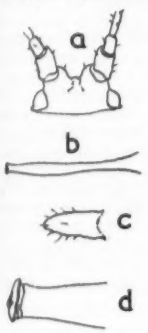


Fig. 2. *Amphorophora rubi* (Kalt.), apt. v. ♀
a. Head. b. Siphunculus. c. Cauda. d. Apex of siphunculus, further enlarged.

ECONOMY

Amphorophora is associated biologically with Rosaceae and ferns. The only important British species is *A. rubi* (Kalt.), which is a vector of virus diseases of raspberries. It is a very slender pale green to whitish-green species living under the leaves of *Rubus* spp., with long, slender and only very slightly swollen siphunculi. It can be distinguished from *A. ampullata* Buckton, living on ferns, by the absence of fine spinules between the hairs at the tibial apices. *A. rubi* has also been recorded from strawberries under the name of *A. fragariella* Theob. *A. gei* (Börner), living only on *Geum* spp., is a much stouter species with more strongly swollen siphunculi. The genus *Masonaphis* H.R.L. on azaleas, sometimes found on imported plants in Britain, might be confused with *Amphorophora* until the presence of a well-marked zone of reticulation at the apex of the siphunculi is noted in the former genus.

LITERATURE : Hille Ris Lambers (*Temminckia* **8**, 224).

APHIS Linnaeus

In recent papers, Börner puts the species hitherto placed in *Aphis* into several genera such as *Doralis* Leach, *Cerosipha* Del G., *Doralina* Börner and *Doralida* Börner, which are here regarded as full synonyms. It is quite impracticable to try to separate them for everyday purposes.

GENERIC CHARACTERS

Moderately large to very small aphids, generically of very constant form, but specifically very variable and with the species-limits often obscure. Colour extremely variable, from pale whitish-yellow to black, with varying amounts of white wax powdering or spot markings. Frons medially somewhat convex with lateral prominences very low, so that the whole outline is gently sinuate. Antennae shorter than body, imbricate, processus terminalis not more than 3½ times basal part of VI. Spinal tubercles always absent, marginal tubercles variable, but present at least on pronotum and abd. I and VII, often also on other segments ; variable in shape, from acutely conical to broad and flat. Abdominal pattern in apterae varying from completely membranous, except for a narrow sclerotic band across each of last two tergites, to solidly dark pigmented (but not very sclerotic) with marked reticulate pattern. Sclerotic pattern most often confined to narrow segmental bars in both apterae and alatae, with marginal sclerites from II to IV in alatae. Siphunculi sub-cylindrical or slightly tapering, from very short to fairly long, imbricate, with a more or less distinct, but never very marked flange apically. Cauda elongate digitate to rather short and bluntly triangular, or in one group on Papilionaceae, sometimes rather thin, tending to acuteness. Alatae with rhinaria on ant. III only, or on III and IV, occasionally with an odd one or two on V ; apterae typically without rhinaria, but occasionally with some present towards the apex of III and on IV. Hairs variable, but never markedly capitate. *Toxopterina* Börner, living on roots of Anthemideae is closely related to *Aphis ;* but it has a longer processus terminalis (more than four times base of VI), its cauda is rather acutely triangular, and the median vein in the forewing of the alata is only once-branched (twice-branched in *Aphis*).

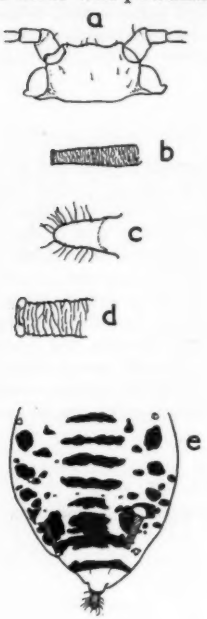


Fig. 3. *Aphis fabae* Scop., apt. v. ♀
a. Head. b. Siphunculus. c. Cauda. d. Apex of siphunculus, further enlarged. e. Abdominal pattern of *A. fabae*, al. v. ♀ (gynopara).

ECONOMY

Biologically, *Aphis* is very heterogeneous, and even very closely related species are frequently associated with widely different primary hosts (e.g., *A. fabae* and *A. viburni* on Celastraceae and Caprifoliaceae respectively). In Britain the only two groups of any economic importance are inadequately described : they are the so-called " Black Aphids " of the " *fabae* group," and the " *rhamni-frangulae-gossypii* group ". Some other species are of importance to horticulturists, fruit growers and others. A list is given below of the main species likely to be met with by economic entomologists, with their most frequent economic hosts.

Species	*Primary host*	*Secondary host*
Aphis fabae Scop. ..	*Euonymus europaeus* ..	Beans, sugar beet ; also dock, poppies, goosefoot, etc.
A. euonymi F.	*Euonymus europaeus* ..	Rhubarb ; also dock, *Solanum nigrum*, etc., *not* beans.
A. rhamni B. de F. ..	*Rhamnus catharicus* ..	Potato ; also dock, comfrey, etc.
A. frangulae Kalt. ..	*Frangula alnus*	Potato ; also *Polygonum*, etc.
A. gossypii Glover ..	None	Cucurbitaceae, etc., often in glasshouses ; cotton in other countries.
A. forbesi Weed. ..	Strawberry	None.
A. grossulariae Kalt. ..	Gooseberry	*Epilobium*
A. varians Patch. ..	Black currant	None.
A. pomi de Geer ..	Apple, hawthorn, *Sorbus aucuparia.*	None.

Species	*Primary host*	*Secondary host*
A. idaei V.d.G. ..	.. Raspberry ..	.. None.
A. ruborum (Börner)	.. Blackberry ..	.. None.
A. sambuci L. ..	.. *Sambucus nigra* ..	.. *Dianthus* and other Caryophyllaceae, *Saxifraga* ; also dock.

LITERATURE : The papers existing on *Aphis* are at present far too scattered and incomplete to be usefully quoted here. Identification should be confirmed by a taxonomist whenever possible. The papers of F. H. Jacob (listed below) on the Black Aphids and *A. sambuci* and their biology should be read as a precaution against attempts to draw distinction between small batches of material.

JACOB, F. H. (1945). Note on the Classification of the British Species of " Black Aphides ". *Proc. R. ent. Soc. Lond.* (B), **14**, 102.

(1947). An Account of a Black Aphid *Doralis fabae* (Scop.) subsp. ssp. *armata Hausmann* on *Digitalis purpurea*. *Bull. ent. Res.*, **37**, 431.

(1948). An Account of a " Black Aphis ". *Aphis ulicis* Walker, 1870. *Proc. R. ent. Soc. Lond.* (B), **17**, 57.

(1949). A Study of *Aphis sambuci* L., and a Discussion of its bearing upon the Study of the " Black Aphids." *Proc. R. ent. Soc. Lond.* (A), **24**, 90

AULACORTHUM Mordvilko

The genus *Myzus* of Theobald (**1**, 283) includes the species now placed in *Aulacorthum ;* many of the species described by Theobald (e.g., *M. mercurialis*, *M. pseudolamii*, *M. chelidonii* (nec Kalt.), *M. veronicellus*), are synonyms of *A. solani* (Kalt.), called, by Theobald, *Myzus pseudosolani* Theob.

GENERIC CHARACTERS

Medium-sized, oval, yellowish, green or pinkish-red, sometimes brownish tinged or whitish. Frons with lateral prominences well developed, their inner margins a little concave, practically parallel apically ; median prominence almost completely absent. Head distinctly spinulose. Antennae in apterae with 0–5, most commonly with 1 or 2 rhinaria at base of joint III ; rhinaria in alatae along III only or on III and IV (subgenus *Neomyzus*). Apterae with dorsal cuticle smooth, not rugose as in *Myzus*. Dorsum not usually pigmented in apterae, but sometimes with a diffuse brownish pigmentation in cold weather forms'; in the subgenus *Neomyzus*, however, there is a very distinctive horseshoe-shaped blackish pattern which is entirely characteristic. In alatae there is more or less developed sclerotic pattern consisting of segmental bars and intersegmental muscle plates which may be fused to some extent, and which together form a rather characteristic pattern. Siphunculi rather long, nearly cylindrical, with a very marked apical flange, but no clear preapical reticulations, at most two or three striate imbrications. Cauda rather short and blunt, with few hairs. The body hairs are small and fairly acute or a little blunt, but not capitate. *Aulacorthum* is hard to separate generically from *Microlophium* on *Urtica* (see under *Acyrthosiphon*), which has rather the same kind of siphunculi and frontal structure ; however, except in aphids found on nettles, this is not of great importance, and need not be discussed further here.

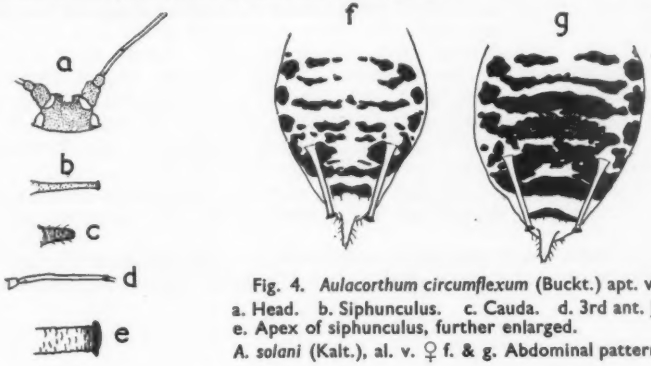


Fig. 4. *Aulacorthum circumflexum* (Buckt.) apt. v. ♀
a. Head. b. Siphunculus. c. Cauda. d. 3rd ant. joint.
e. Apex of siphunculus, further enlarged.
A. solani (Kalt.), al. v. ♀ f. & g. Abdominal patterns.

ECONOMY

The two species of importance to economic entomologists in Britain are both very polyphagous ; one is apparently entirely viviparous and never produces sexuales, while the other has the rare attribute of being able to overwinter, as eggs, on a number of widely different hosts. This latter, *A. solani* (Kalt.), is a pale to dull green species, usually without apparent markings in the apterae, but rarely in winter with a diffuse brownish suffusion of the dorsum. A conspicuous feature in life are the blackish, widely flanged tips to the siphunculi. *A. solani* is common on potato, and is a potential virus transmitter, but is rarely common enough to be important. It can be separated from *Myzus persicae* by the cylindrical siphunculi, the non-converging frontal prominences and the rather shiny green immature forms, immature alatae also being green, while in *M. persicae* they are reddish. The other economic species, *A.* (*Neomyzus*) *circumflexum* (Buckton), is well known from its very distinctive horseshoe mark on the dorsum in apterae. In glasshouses it may be a pest on a wide variety of plants, including Orchidaceae and Liliaceae.

LITERATURE : Hille Ris Lambers (*Temminckia*, **7**, 307 and **8**, 182).

(*To be continued*)

INTERNATIONAL PLANT PROTECTION CONVENTION

The International Plant Protection Convention of 1951, which was signed by some thirty countries, including the United Kingdom, at the Seventh Session of the F.A.O. Conference held in Rome from November 19 to December 7, 1951, supersedes and replaces the similar but obsolete Convention that arose out of an International Conference of Plant Protection held in Rome in 1929. It is an effort to create a broad and flexible international agreement on plant protection which can easily be adapted to meet changing conditions.

Each contracting Government undertakes to establish an official plant protection organization charged with the inspection, among other things, of growing plants and areas under cultivation, as well as with the issuing of phytosanitary certificates. Certificates covering materiai intended for planting or propagation must conform with the model given in the Annex to the Convention. Each Government also undertakes to make provision for the distribution of information about the diseases and pests of plants and plant products, and for research in the field of plant protection. Authority is given to regulate import of plants and plant products and to prescribe restrictions or regulations, provided they are based solely on phytosanitary grounds. Provision is also made for supplementary agreements and the settlement of disputes.

The establishment of regional plant protection organizations within the framework of the F.A.O. general world scheme is contemplated. The European Plant Protection Organization (E.P.P.O), formally set up in Paris in April, 1951 is already regarded as the regional organization for Europe.

PRINCIPLES UNDERLYING PLANT IMPORT AND EXPORT REGULATIONS

by W. C. MOORE

Plant Pathology Laboratory, Harpenden, Herts

Pests and plant parasites are merely those members of the fauna and flora which attack plants of economic value, and just as each country has its own particular fauna and flora, so each country has its own pests and parasites. Some of these have become common to many countries, but there are many which are still restricted to a few countries or to a single continent, and which may be prevented from freely spreading further by natural geographical barriers such as deserts, mountains or oceans. Nevertheless, if diseases and pests are artificially transported, the range of many of them can undoubtedly be greatly extended, and experience has shown that when they do reach new countries they are frequently much more injurious than in the old ones. Moreover, organisms that are regarded as harmless in one country may become injurious parasites when introduced into another. The spread to new areas may occur by means beyond man's control, such as by carriage of insects and fungus spores in air currents, but usually it takes place as a result of importing infected plant material. Consequently, most countries have, at one time or another, issued regulations or taken quarantine measures designed to prevent, or at least to hinder, the introduction of plant diseases and pests into their territories.

In the past it has mostly been left to the importing country to impose the safeguarding measures it thinks fit, and with a few notable exceptions the exporting country has been content to satisfy those requirements in more or less exemplary fashion. The regulations themselves are sometimes open to criticism, even when made in good faith, for they have frequently been based on fear of the unknown rather than on sound biological grounds. Again, some import regulations inevitably give trade protection to the producer in the importing country which may be more valuable than that obtained from a high tariff. Consequently, there may be, on the one hand, a great incentive to introduce or maintain stringent regulations when they are not justified on scientific grounds, and, on the other, a tendency to regard quarantines merely as trade barriers to be evaded or broken down by bargaining irrespective of the scientific merits of the case. With the greatly increased interest now being taken in regulations governing international traffic in plants, it is desirable to consider some of the principles that should underlie the establishment of plant protection regulations governing the import and export of plants.

In the first place, it should be an obligation on every country to take all reasonable steps to prevent the export of insects, fungi and other organisms likely to harm crop plants. This requires a properly organized and fully trained phytopathological service capable of carrying out the inspection of nurseries and other establishments supplying plants, and of issuing health certificates, much along the lines already envisaged in the International Plant Protection Convention, agreed at the Sixth Annual Session of F.A.O. in Rome in November 1951. There should be no justification for exporting material known to be infected with an injurious insect or fungus because it happens fully to conform in other respects with the requirements of the importing country.

Secondly, it should be a responsibility of the importing country actively to control the importation of plant material likely to introduce potentially harmful

organisms. It is not sufficient to rely solely on health certificates, and it is legitimate and desirable to institute a process of check inspections, or, if necessary, to detain, treat, destroy or refuse entry to diseased consignments.

Adequate training of the staff necessary for this work is vital if these two principles are to be put into practice. It should be recognized that ability of a high order is needed not only for academic research, but also for field and extension work and the carrying out of quarantine and regulatory functions. An imposing phytopathological service can be worse than useless unless the individual workers of which it is composed are properly qualified.

A third important principle is the need for a practical and commonsense approach to the problem. No export or import regulations will entirely prevent the transport of insects, fungi and other parasites from one country to another. Pests may be transported, unattached to merchandise, in ships, trains, or aircraft ; plants may act as symptomless carriers of viruses ; and fungus spores or insects may be carried in air currents. Health certificates, however worded, can never provide absolute guarantees. The value of these certificates depends not so much on their preventing the arrival of a particular pest or disease but on preventing its arrival continually and in appreciable quantities. It is true a single introduction of a foreign pest or disease may possibly lead to its establishment, but numerous introductions, comprising many individuals of the species, are far more likely to bring this about. In short, the health certificate system reduces risks but does not eliminate them, and it is best regarded as a useful compromise in the interests of international trade. If the trade in a particular commodity is of little or no value and involves serious phytopathological risks, an embargo would be preferable, for it gives the greatest possible measure of insurance against foreign pests and diseases. But the balance between promoting international traffic in healthy plant material and stopping it altogether is a very delicate one.

Admittedly it is sometimes very difficult to judge the potentialities of an organism, and even with a single parasite of almost world-wide distribution there is always the risk of introducing new strains. Nevertheless, unless plant protection restrictions are defined in such a way as to avoid covering any and every fungus, insect, eelworm or virus, known or unknown, injurious or innocuous, all attempts by international co-operation to achieve something of mutual advantage would seem to be doomed to failure. Moreover, there is a real risk that the steps taken by importing countries, if too severe, may leave them worse instead of better off, for they may be forced to look for their planting material, not to countries with the best reporting services and a determination conscientiously to abide by the regulations laid down and agreed, but to countries which have only rudimentary reporting and inspection services, or which are prepared to interpret the requirements loosely. Again, a stage may be reached where the cost of applying the regulations cannot be justified by the total value of the plant material to be exported.

Acceptance of the principles outlined, and recognition that the responsibility is international, should facilitate the task of placing import regulations on a more uniform and scientific basis than has existed hitherto. But uniformity must not be pressed too far. A common health certificate, internationally adopted, would be a great convenience, provided its true value is recognized. It can do little more than certify reasonable freedom from all injurious pests and diseases, though its value is undoubtedly enhanced if it is based on inspection of the growing crops as well as on the usual pre-export examination. To the adoption of the common certificate must be added more stringent measures,

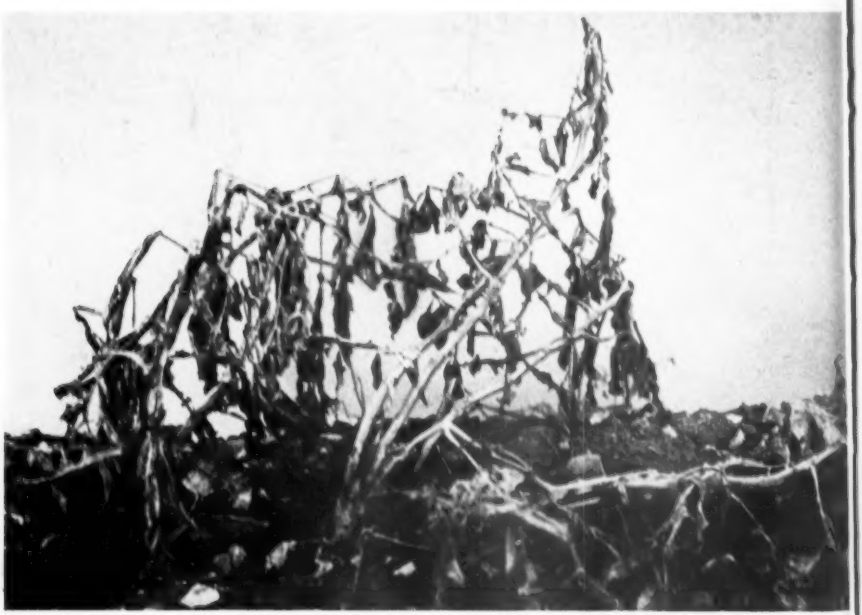
CONTROL OF MILLET SMUT

(*see pp. 29–30*)

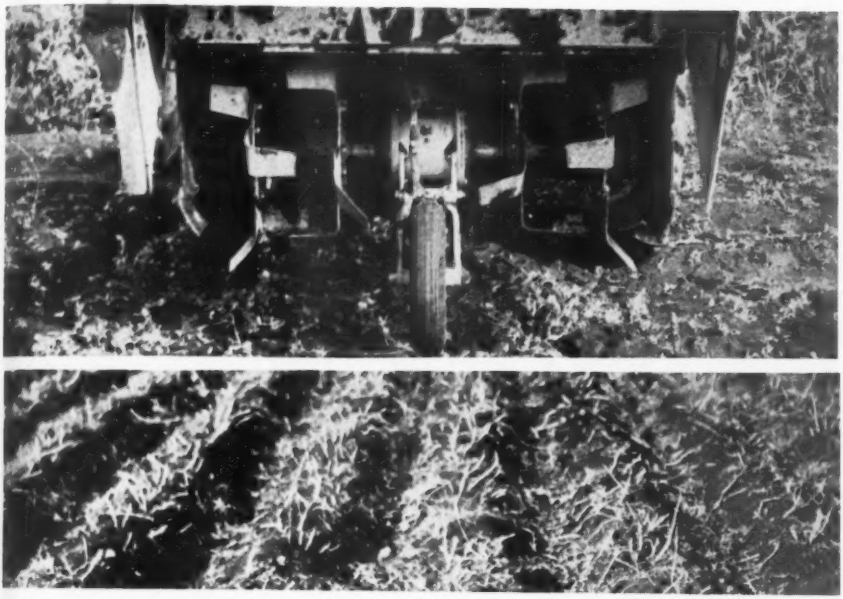
Millet Smut (*Sphacelotheca destruens* (Schlecht). Stevenson & Johnson).
Healthy head on left, smutted head on right.

PLATE I

1. Majestic, 5 days after burning off with Tar Oil Fraction TOF 54.



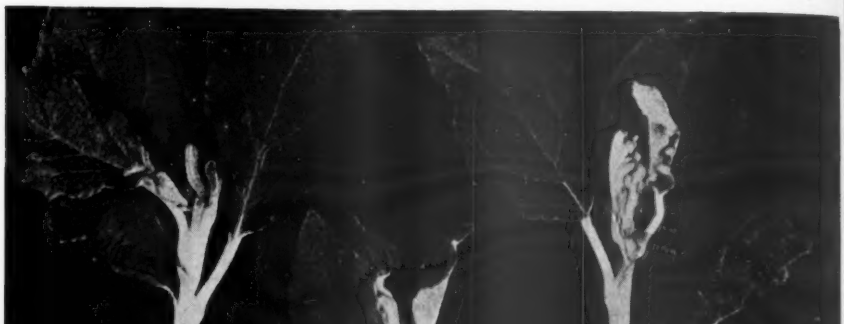
2. Majestic, 5 days after burning off with Sulphuric Acid



1. Cutters of the Howard Potato Haulm Pulverizer, and drills of King Edward, 5 days after cutting. Isle of Ely centre.

2. The Bettinson Potato Haulm Cutter at work on sprawling Majestic. Rothamsted centre.

TORTRIX *CNEPHASIA LONGANA* ON FRUIT TREES (*see p. 31*)



1. Tortrix Caterpillar (*Cnephasia longana*) Damage to apple shoots.

RABBIT REPELLENTS FOR FRUIT TREES (*see pp. 18–23*)

V. Severe Severe. Moderate. Slight. None.

2. Degrees of rabbit damage on apple rootstocks.

PLATE IV

directed against particular pests and diseases, and involving perhaps embargoes on certain plant genera. For this there can be no rigid international uniformity. What is looked upon by one country as potentially a serious pest or disease, may be regarded by another as of little or no account, perhaps because the host plants are not of economic importance, or because enough is known of the biology of the parasite to justify disregarding it.

Plant import restrictions ought, in fact, to be based, not as in the past mainly on arbitrary rulings, but on sound biological grounds, and they should be arrived at by consultation and agreement among technical officials and scientists with special knowledge of the pests and diseases involved. There seems to be no point, for instance, in laying down and enforcing stringent import regulations about potato root eelworm, if it is certain that the eelworm could not establish itself under the climatic and soil conditions prevailing in the importing country. Nor is it always necessary for an importing country to impose identical restrictions on all exporting countries to guard against the same parasite. The British Government is concerned to prevent the establishment in Britain of cherry fruit fly (*Rhagoletis cerasi*) and therefore places restrictions on the import of cherries during the period of the year when there is a risk of introducing the fly. That period, however, may differ for different countries and even for different districts within the same country ; consequently the restrictions imposed on one country can legitimately be different from those imposed on another. Wide disparity between the efficiency of the reporting and inspection services of two countries may also be regarded as a legitimate reason for discrimination in the application of regulations.

Mutual understanding of the interpretation to be placed on plant protection regulations is essential in plant regulatory work, and it is perhaps best to leave this for separate agreements between the importing and exporting countries concerned, instead of attempting to lay down a lengthy and uniform procedure in the regulations themselves. If, for example, an importing country requires a declaration that the planting material it imports has been grown in soil free from potato root eelworm, agreement must be reached on the precise meaning of the declaration. Assuming it is based on soil sampling, agreement must be reached on details of the method and frequency of sampling, and it must be recognized that by no known sampling method can a guarantee be given that soil is *free* from eelworm cysts. An increasing number of countries are now calling for field inspections of growing plants destined for export and if freedom from injurious pests and diseases is to be required, an interpretation must be placed on this phrase, for no nursery is spotless.

With the greater interest now being shown in rational plant protection regulations, it would be very helpful if a code, embodying the scientific principles concerned and internationally recognized, could be prepared. Such a code, to which all countries could adapt their import regulations, should aim at defining precisely the circumstances under which restrictions on imports are scientifically desirable, so that countries are not free, without obviously infringing the code, to issue regulations more drastic than the circumstances warrant, or less stringent than is desirable in their own or their neighbour's interests. It is just as undesirable to neglect to take essential precautions as it is to impose an embargo that is not fully justified on plant pathological grounds.

RABBIT REPELLENTS FOR FRUIT TREES

by HARRY V. THOMPSON AND C. J. ARMOUR

Infestation Control Division Laboratory, Hook Rise, Tolworth, Surrey

Some damage to fruit trees, chiefly apple and pear, caused by rabbits (*Oryctolagus cuniculus*) and hares (*Lepus europaeus*) is regarded by growers as inevitable, and all orchard capital expenses include a charge for rabbit netting. This usually has to be ripped up and renewed about every twelve years. East Malling Horticultural Research Station, for example, is entirely netted in, and some of the individual plots are given additional rabbit-proof fences. Once rabbits, or hares, get into an orchard by burrowing under or jumping over the netting, or through open gates, and begin barking trees, they need to be immediately destroyed. Many valuable trees, even those which are 10 to 20 years old, may be ring-barked (girdled) in a single night, and while they can be saved by grafting young shoots across the injury, the grafts themselves are liable to similar damage unless treated with a repellent.

Rabbit netting, the usually recommended form of protection, is expensive and by no means infallible ; if it is used as a boundary fence, rabbits may go under it or hares over it ; if used as individual tree guards, it protects only the trunk and not the branches. Moreover, it may be rendered quite ineffective by a heavy fall of snow.

Although the idea of the use of rabbit repellents must be one that has long appealed to fruit-growers, and although many formulae are known and several commercial products are on sale, little experimental work has so far been done in this country. The properties of a good repellent are that it should be easy to apply, remain effective throughout the dormant season, and not injure trees.

PREVIOUS RESEARCH

Cottontail rabbits (*Sylvilagus* spp.) and black-tailed, white-tailed and snowshoe hares (*Lepus* spp.) have all been reported as attacking the bark of growing trees and shrubs in North America, and many repellents have been tested there over the past twenty years. Harvey (1931) praised sulphurized oil (species of lagomorph not named), and Neilson (1933) found that resin and linseed oil in the proportion of 5 : 1 gave protection (against unrecorded species) but caused injury to sweet cherry and peach trees.

Following on Neilson's work, Cardinell, Toenjes and Hayne (1941) tested over 200 materials. At first they used large enclosures, 40 ft. square and containing several cottontails which were fed lightly, and the repellents were painted on trunks or cut branches of fruit trees. The first repellent found to be both safe and effective was a mixture of resin (7 lb.) and ethanol (1 gal.), the cheaper grades of both substances proving satisfactory. A single application, made in the autumn, gave protection to trees throughout the winter. Trees treated with resin-linseed oil showed restricted growth. Further tests by Cardinell and Hayne (1947) were made in small pens, each containing a single rabbit ; but the results from pen tests are strictly comparative only within each pen, since the amount of bark eaten per repellent depends on the relative acceptability of other treatments. Work in the United States on cottontails carried out by Allen (1939), Dalke and Sime (1941), Hoseley (1942) and Sweetman (1944, 1946), shows that the diet of the cottontail differs from place to place, and is determined by available food, and possibly also by local or individual

preferences. This probably accounts for varying reports of the effectiveness of the several compounds.

Of those tested by Cardinell and Hayne, the following repellents were the most promising, and were as good as a resin-ethanol 2 : 1 by weight mixture: resin-ethanol 3 : 2, rabbit repellent 96A (made by the United States Fish and Wild Life Service), and four commercial products. Garlough, Welch and Spencer (1942) claimed that several repellents were effective against both *Sylvilagus* and *Lepus* spp., but only one of these mixtures, since modified and now known as 96A, is among the best half-dozen of those tested by Cardinell and Hayne. It contains five components (resin, asphalt emulsion, copper sulphate, copper carbonate and lime-sulphur) with ethylene dichloride as a solvent. Recent tests by Baumgartner and Powell (1949), of a commercial deer repellent—a zinc dimethlydithiocarbamate-cyclohexylamine complex—have shown promising results, and this substance is claimed also to be an effective rabbit repellent. Investigations carried out in Canada (Kerr, 1948) have confirmed the value of compound 96A and resin-ethanol as rabbit repellents.

For trials at East Malling Research Station, Kent, (Coker, 1951), samples of three rabbit repellents were obtained from the United States : a commercial deer repellent of unknown composition ; another commercial deer repellent ; ZDC (zinc dimethyldithiocarbamate-cyclohexylamine complex and polyethylene polysulphide suspension) ; and compound 96A. Bundles of Cox's Orange Pippin shoots were tied together, treated with the various repellents and laid out in a statistically-planned trial on parts of the research station infested with rabbits. The shoots were observed at weekly intervals for four weeks and an analysis was made of the number of bites of bark, and of the number of tips bitten off. Compound 96A gave significantly better results than the three other materials, although in later tests of phytotoxicity, it slightly delayed callus formation on wounds made and treated late in the dormant season.

TRIALS ON APPLE ROOTSTOCKS

Preliminary screening tests having been done—although often with species of rabbits different from those occurring in this country—a field trial, rather than pen tests, was the method chosen for further work. The four materials selected for trial were : the rabbit repellent 96A ; the deer repellent, ZDC, which is claimed by the makers to repel rabbits also, and which was used at 8 per cent. in water (twice the recommended strength) ; bone-oil, a persistently aromatic fluid obtained by the destructive distillation of bones ; and resin-ethanol, 8 lb. commercial resin (colophony) to 1 gal. of denatured ethyl alcohol (i.e., approximately 1 : 1, by weight).

Two hundred and sixty apple rootstocks (Malling No. 2) were planted at 2-ft. intervals, in rows 2 ft. apart, in pasture adjoining rabbit-infested scrub which consisted of elder, hazel and birch, both the hazel and the birch having suffered considerable damage from rabbits. Forty-four untreated (control) stocks formed a grid which divided the treated stocks into six groups of 36. Each group was further divided into four blocks of 9 rootstocks, and each block was treated, in a random manner, with one or other of the four repellents. The repellents were applied with paint brushes, and the entire stock was treated. The rootstocks were examined at weekly intervals for 15 weeks, from November 15, 1950, to February 27, 1951. All the areas bitten by rabbits were sketched on rootstock diagrams. Where the damage was extreme, and the sketches

became too complicated to be continued, they were replaced by estimates of the areas denuded of bark. Notes were kept of lopping caused by rabbits biting off, sometimes repeatedly, the top few inches of a rootstock. At the end of the experiment, the damage, apart from lopping, was graded weekly for the top, middle and bottom thirds of the rootstocks, according to the following scale :

Grade	*Degree of damage*	*Area of damage*
0	None	Less than 1 sq. cm.
1	Slight	More than 1 sq. cm., but less than one-sixth of the surface area.
2	Moderate	More than one-sixth, but less than one-third of the surface area.
3	Severe	More than one-third, but less than half of the surface area.
4	Very severe	More than half of the surface area, or completely ringed.

Since most of the rabbit damage was on the bottom thirds of the rootstocks, these portions are considered in detail. The degrees of damage are illustrated in Plate IV, 2. The average height of the rootstocks was 3 ft.

Fig. 1 shows the progress of total damage, i.e., the percentage of the rootstocks with each treatment which showed *any* degree of damage on the lower thirds of their lengths, at the end of each week of the experiment. Fig. 2 shows the corresponding progress of *severe* and *very severe* damage only.

Table 1 gives the mean percentages of the rootstocks with *any* degree of damage (total damage), and with *severe* and *very severe* damage, on the lower third, at the end of the experiment.

TABLE 1

PERCENTAGE OF ROOTSTOCKS SHOWING RABBIT DAMAGE 15 WEEKS AFTER TREATMENT

Treatment	Total Damage *per cent.*	Severe, and Very Severe Damage *per cent.*
96A	69	33
ZDC	100	91
Bone oil	52	13
Resin	31	2

An analysis of variance was carried out on the data using an angular transformation (Fisher and Yates (1948)), the controls being omitted since they were not an integral part of the design. The variance ratio between treatments, for both total, and severe and very severe damage, was significant at the 0·1 per cent. level, and that between blocks was not significant at the 5 per cent. level. Both total and severe and very severe damage on rootstocks treated with ZNC were significantly greater (at the 0·1 per cent. level) than on those treated with the other materials. Total damage to rootstocks treated with 96A was significantly greater (at the 1·0 per cent. level) than that with resin, and total damage with the bone-oil treatment was significantly greater (at the 5 per cent. level) than that with resin. Severe and very severe damage with the 96A treatment was significantly greater (at the 5 per cent. level) than that with the bone-oil treatment, and also significantly greater (at the 0·1 per cent. level) than that with resin.

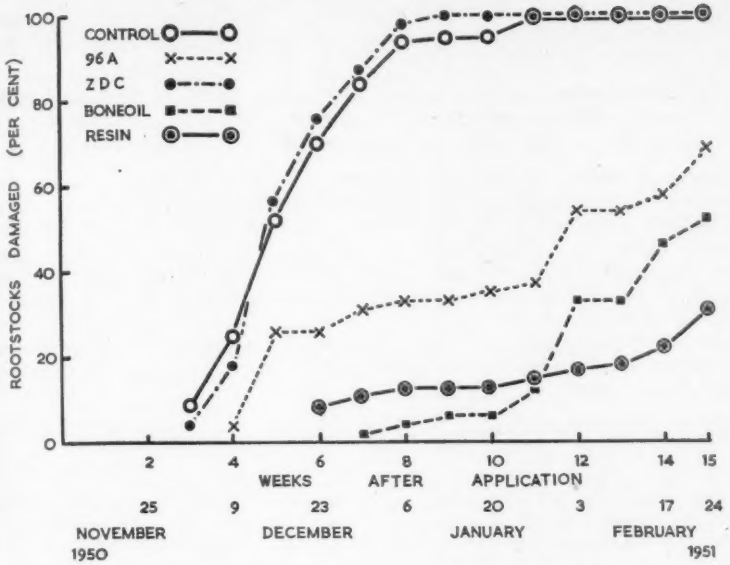


Fig. 1. Total rabbit damage to bottom thirds of rootstocks at weekly intervals.

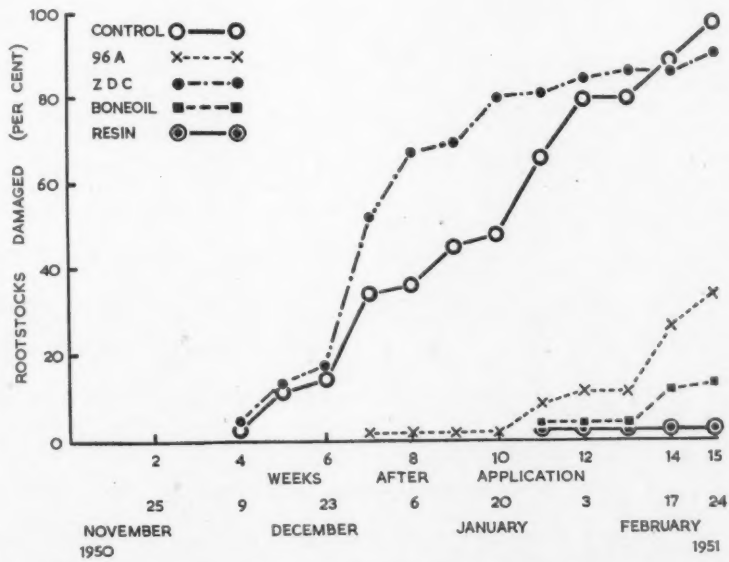


Fig. 2. Severe and very severe damage to bottom thirds of rootstocks at weekly intervals.

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It is clear that rootstocks treated with resin-ethanol are afforded a high degree of protection over the dormant period. Bone-oil was slightly, and 96A even less, repellent, while ZDC gave no protection at all.

The rabbit damage was not concentrated on any one block of rootstocks, but was spread generally over the entire area of the experiment. Snow fell on four occasions, but this could not be correlated with any increased damage.

Figures for damage to the middle and top of the rootstocks reflected, on a smaller scale, the results from the bottom thirds of the rootstocks, except that ZDC-treated stocks suffered more damage than did the controls. The damage caused by rabbits lopping off the tops of the rootstocks was recorded weekly and, after 15 weeks, counts of lopped stocks (out of 44 for the untreated, and 54 for each of the treatments) were as follows : Untreated, 21 ; 96A, 7 ; ZDC, 33 ; Bone oil, 15 ; Resin, 10. After the first three weeks, damage gradually increased up to the fourteenth week ; then, in the fifteenth week, there was a sudden jump in the amount of damage in all plots except those with the 96A treatment.

Grateful acknowledgment is made to Dr. H. B. S. Montgomery and to Mr. E. G. Coker, of East Malling Research Station, for much help in planning the experiment, and for supplying the rootstocks ; to Dr. S. C. Pearce, of East Malling, and to Mr. E. A. Maddison, of Wye College, for assistance with the experimental design and statistical analysis of the results ; to Dr. E. H. Wilkinson, of Wye College, and to his students, for help in planting and treating the rootstocks, and to Miss V. Hudson, of Big Coombe Farm, Hastingleigh, Kent, for allowing the use of a pasture and rabbits. Mr. A. G. Jenson, F.R.I.B.A., kindly prepared the figures.

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SURVEYS FOR CHOKE (*EPICHLOE TYPHINA*) IN COCKSFOOT SEED CROPS, 1951

Contribution from the Conferences of Plant Pathologists and Grassland Officers, National Agricultural Advisory Service, compiled by E. C. Large of the Plant Pathology Laboratory, Harpenden

Choke is a common disease of cocksfoot (*Dactylis glomerata*), both in crops grown for seed and those intended for hay or pasture. It is found in all strains of the grass, and, as it is systemic, with mycelium perennating in the vegetative parts of the plant (Sampson, 1933), it may be present for a season or more before giving rise to any external symptoms. Sooner or later, however, the fungus invades potentially fertile tillers, in the spring, "choking" the inflorescence, and preventing its emergence (Fig. 1). A thin, whitish felt or stroma of the fungus sheaths the base of the uppermost leaf of the infected tiller for a length of an inch and a half or more. This whitish stroma produces the summer spores or conidia of the fungus, and later in the season it thickens and changes in colour to orange or yellow, giving the very characteristic "Reed Mace" appearance from which the fungus took its old popular name. Fruiting bodies or perithecia are produced in the thickened orange stroma.

As it is not common for choke to reduce the amount of herbage, its occurrence is of little significance in pastures. The economic importance of the disease lies in damage to crops grown primarily for seed production (Sampson and Western, 1942). The disease is of long standing in Denmark, and its occurrence in pedigree strains of cocksfoot grown for seed in this country has been the subject of investigation at the Welsh Plant Breeding Station since 1927 (Sampson, 1933). The means by which healthy plants become infected still remains to be established, and research on this aspect of the problem is continuing.

To obtain reliable information on the actual amount of choke in our seed crops, and on its severity in relation to age of stand, and other cultural factors, surveys were made during 1951 on 644 crops, covering in all some 10,000 acres, widely distributed over all the seed-growing areas of England and Wales. The crops entered for inspection under the Certification Scheme for Aberystwyth strains of cocksfoot were used for the purpose of the survey as they covered the wide range of conditions required for an investigation of this kind. The work was carried out by Provincial Plant Pathologists, Grassland Officers and District Officers of the National Agricultural Advisory Service, in collaboration with the Welsh Plant Breeding Station (Gwilym Evans, with T. B. Edwards and H. Roberts) and with the Seed Production Committee of the National Institute of Agricultural Botany (G. W. G. Briggs). The surveys were devised and co-ordinated at the Ministry's Plant Pathology Laboratory at Harpenden, in consultation with G. V. Dyke of the Statistical Department at Rothamsted.

Two inter-related surveys were made: first, an *extensive* survey on all 644 crops by Grassland Officers and District Officers, at the time of their normal inspections for certification and, secondly, an *intensive* survey on a balanced sample of 86 crops in greater detail by Plant Pathologists. Both surveys covered all three of the Aberystwyth strains of cocksfoot, i.e., the hay type S.37, the hay and pasture type S.26, and the pasture type S.143.

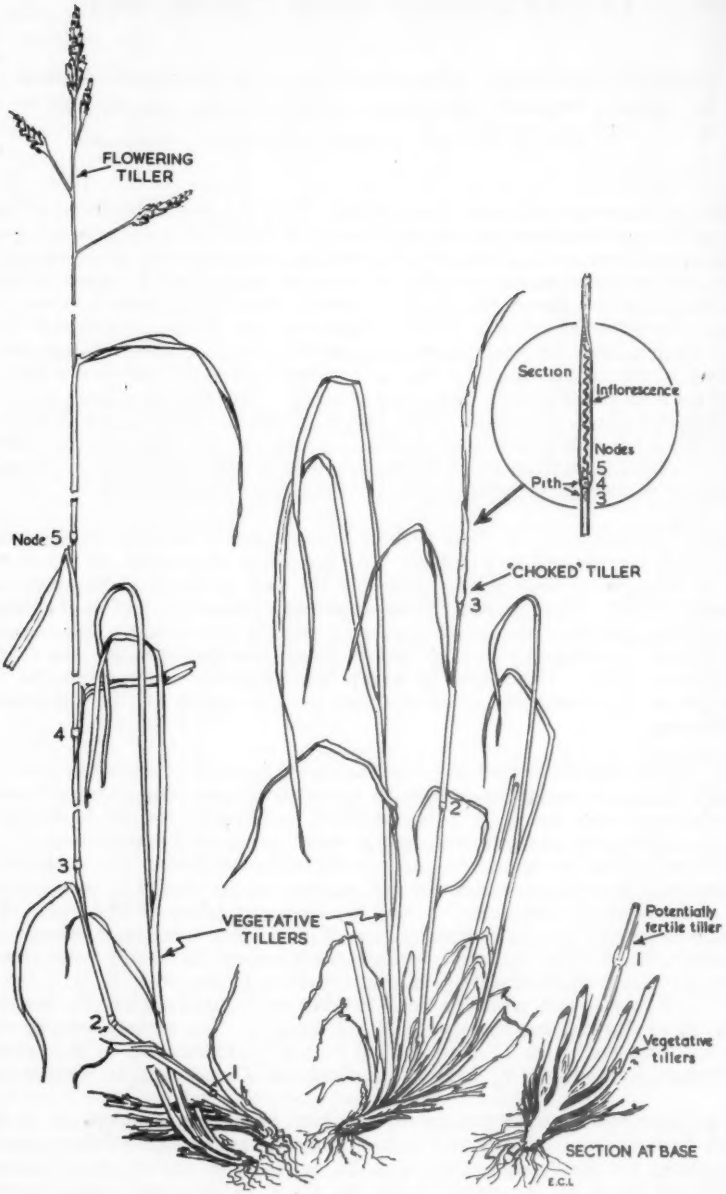

Fig. 1. Healthy and choked cocksfoot plants, showing flowering, choked and vegetative tillers.

Choke in Cocksfoot Seed Crops

Extensive Survey by Inspectors

The inspection of the seed crops, for isolation, trueness to type, freedom from weeds, and general vigour, was done in late May and early June when the plants were in full growth and coming into head. The procedure of inspection was to examine from twelve to thirty 60-ft. row lengths (quadrats) in each field, the quadrats being located according to a systematic sampling plan. For the purpose of the choke survey, additional headings were put on the record forms, and the inspectors were asked to report on the prevalence of choked tillers, and also of vegetative tillers (Fig. 1), in each field, according to the following scale :

Absent—looked for among herbage but not seen in field.
Occasional—a few seen in some quadrats.
Frequent—up to about 10 per cent. in most quadrats.
Severe—over 10 per cent. in most quadrats.

Guidance on the visual assessment of choke was given to the inspectors by D. L. G. Davies and Gwilym Evans at a conference in Aberystwyth before the inspections began, and the majority of the inspectors, despite the rush of work over the inspection period, were able to make good estimates of the prevalence of choked tillers, in accordance with the scale. Of the 644 crops assessed, 20 were in the Northern Province (S. Campbell), 12 in Yorkshire and Lancashire (R. P. Davies), 157 in the East Midlands (O. G. Williams), 52 in the West Midlands (T. W. Evans), 225 in the Eastern Province (H. R. Williams and M. Williams), 140 in the South-Eastern Province (D. J. C. Jones), 30 in the South West (G. M. Davies), and 8 in Wales (A. Rowlands).

Table 1

Occurrence and Severity of Choke in 644 Cocksfoot Seed Crops. Extensive Survey. England and Wales (1951)

(*a*) In relation to harvest year (all strains)

Number of crops with choke	*1st year*	*2nd year*	*3rd year*	*4th year*	*5th and 6th years*
Severe	—	3	4	—	6
Frequent	2	17	12	4	10
Occasional	6	68	26	9	7
Absent	310	112	39	4	5
Total	318	200	81	17	28

(*b*) In relation to strain (all harvest years)

Number of crops with choke	*S.*26	*S.*37	*S.*143	*All strains*
Severe	5	3	5	13
Frequent	14	8	23	45
Occasional	42	27	47	116
Absent	143	129	198	470
Total	204	167	273	644

(*c*) In relation to province (all crops)

Number of crops with choke	*Northern*	*Yorks & Lancs*	*East Mids.*	*West Mids.*	*Eastern*	*South-East*	*South-West*	*Wales*
Severe	2	1	1	0	7	1	1	0
Frequent	5	1	10	0	17	8	3	2
Occasional	9	0	28	12	45	18	3	0
Absent	4	10	118	40	156	113	23	6
Total	20	12	157	52	225	140	30	8

INTENSIVE SURVEY BY PLANT PATHOLOGISTS

For this survey, the crops to be examined were drawn by lot from the list of those entered for inspection, and in such a way that, wherever possible, there were two crops for each harvest year in each province, with a fair proportion of crops of each of the three strains in the whole sample.

The procedure adopted by the Plant Pathologists was to examine 10 lengths of 1-foot run of drill in each field, equally spaced along the field diagonals. A rectilinear U-shaped frame of stout wire, with 1-foot sides, was used to mark off the lengths of drill, and, in each of these lengths, counts were made of the number of flowering tillers, choked tillers, and vegetative tillers, as shown in Fig. 1. The most convenient method of obtaining accurate counts, especially of the number of vegetative tillers, was to take up all the grass lying within the frame, or to cut it very close to the ground, and then to tie up the 10 bundles for each field individually, and examine them in the laboratory.

The work involved was considerable, but, in all, 86 crops were examined in this way, totalling about 1,350 acres. The numbers of crops in each province, and the plant pathologists who made the assessments on them, were as follows : 12 in the Northern Province (H. E. Croxall and D. C. Gwynne), 4 in Yorkshire and Lancashire (A. Beaumont and J. H. Western), 15 in the East Midlands (H. Stirrup, E. Lester, J. P. Cleary and E. R. Wallace), 11 in the West Midlands (N. C. Preston, W. R. Rosser, H. E. Croxall and J. E. E. Jenkins), 15 in the Eastern Province (W. A. R. Dillon Weston), 16 in the South-Eastern Province (W. Buddin, H. H. Glasscock, E. T. Roberts and J. J. Walker), 8 in the South-Western Province (L. Ogilvie and A. Robertson), and 5 in Wales (D. L. G. Davies, J. Rees and J. B. Jones). The main results are presented in condensed form in Table 2, and in the scatter diagram, Fig. 2.

TABLE 2

*PERCENTAGE OF CHOKED TILLERS IN 86 COCKSFOOT SEED CROPS. INTENSIVE SURVEY. ENGLAND AND WALES (1951)

(*a*) In relation to harvest year (all strains)

*Percentage of choked tillers**	1*st year*	2*nd year*	3*rd year*	4*th year*	5*th and 6th years*	*All years*
41–70	—	—	—	—	5	5
21–40	—	—	3	1	2	6
11–20	—	2	3	0	6	11
1–10	1	5	7	6	3	22
0·1–0·9	0	4	2	3	0	9
Nil	19	10	3	0	1	33
Total no. of crops	20	21	18	10	17	86

(*b*) In relation to strain (all harvest years)

*Percentage of choked tillers**	*S.*26	*S.*37	*S.*143	*All strains*
41–70	—	2	3	5
21–40	1	0	5	6
11–20	0	5	6	11
1–10	8	1	13	22
0·1–0·9	3	4	2	9
Nil	9	9	15	33
Total no. of crops	21	21	44	86

* Percentage of choked tillers $= \frac{\text{Choked tillers}}{\text{Choked} + \text{Flowering tillers}} \times 100$

Although the more critical and time-consuming methods, used in the plant pathologists' survey, revealed, as was to be expected, a higher incidence of choke in some fields, than did the inspectors' survey which was based on simple eye-assessment, the two kinds of survey gave the same main indications. Both showed that, with one or two very significant exceptions, choked tillers were absent in first-year stands, that they were present in about half of the second-year stands, and present in most of the stands in the third and later years, irrespective of strain.

There was also a progressive increase in the number of choked tillers with age of stand. In the plant pathologists' survey, the proportion of crops showing 10 per cent. or over of choked tillers ranged from 9 per cent. in the second year to 76 per cent. in the fifth and sixth years. In the inspectors' survey, the proportion of crops in which choke was assessed as " Frequent " or " Severe " rose from 10 per cent. in the second year, to 58 per cent. in the fifth and sixth years. In this, the two surveys showed good agreement.

There was no indication of any appreciable difference between the mean incidence and the severity of choke found in the different provinces, and no consistent indication of any difference in susceptibility as between the three strains.

It was noted, in the course of the survey, that many of the older stands tended to be full of weed grasses and were unproductive for reasons other than the presence of choke.

EFFECT OF CHOKE ON THE NUMBER OF VEGETATIVE TILLERS

There are some grounds for expecting that a high percentage of choked tillers in a crop may tend to increase the number of vegetative tillers by diverting the energy of the plants from the production of seed heads to that of herbage. Plants with choked tillers tend to show a more luxurious growth than those without choke, but whether this is due to an increase in number, or in length and vigour, of the vegetative tillers, has not been established. When the numbers of vegetative tillers in the crops of the plant pathologists' survey were plotted against percentage of choked tillers, there was no indication of any correlation. Over a wide range of choke infection, the number of vegetative tillers, per foot-run of drill, varied from less than 20 to over 200, and it is probable that the number of vegetative tillers was so greatly affected by the management of the crops, as regards date of sowing, autumn burning-off, grazing, etc., that the effect of choke, if any, on the production of herbage was almost completely masked.

EFFECT OF CHOKE ON THE NUMBER OF FLOWERING TILLERS

The scatter diagram (Fig. 2), for number of flowering heads against percentage of choked tillers, in the plant pathologists' survey, shows a good correlation. The number of flowering tillers per foot of drill, in the crops in which choke was absent, ranged from 10 to over 120, but most of the points were clustered about the mean of 62 flowering tillers per foot-run, for all strains. For the group of crops averaging 51 per cent. of choked tillers, the mean number of flowering tillers was 29·3, or about half that for the crops free from choke.

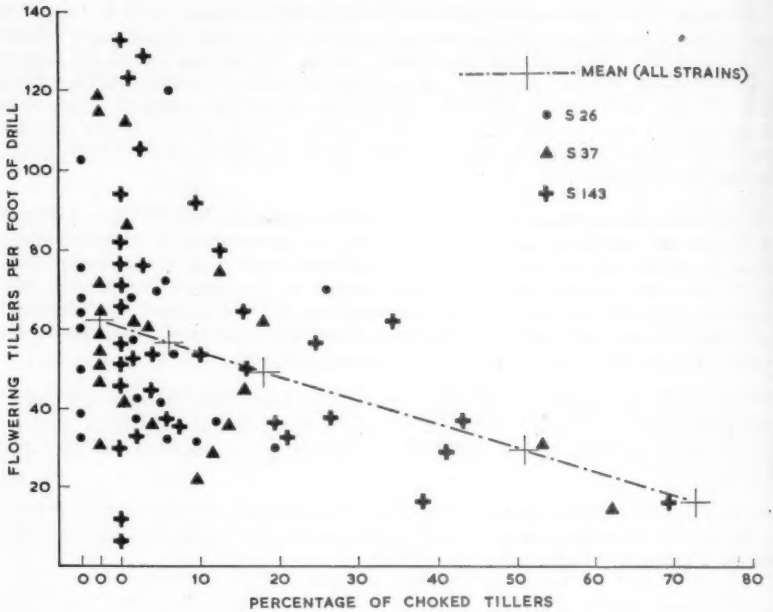

Fig. 2. Scatter diagram showing percentage of choked tillers and mean number of flowering tillers per foot of drill for crops in the Plant Pathologists' Survey.

A similar relation was shown for other levels of choke infection. The survey therefore indicated that the percentage of choked tillers in a field may be a fair measure of the reduction caused by choke in the number of seed-heads to be harvested, i.e., that there is little or no compensatory effect tending to increase the number of flowering heads when some tillers are choked, and little or no systemic effect tending to reduce the number. The actual stand of flowering heads in any field, however, is determined by many factors other than choke, and most poor stands are the result of sowing on overcropped land, fertilizer starvation, grazing, or faults in management.

This is an interim report of the first year's work on surveys which were begun in 1951 and are being continued. The weather conditions of 1951 were unusual, particularly in that soil temperatures were abnormally low in the spring. Seasonal influences on the incidence and severity of choke remain to be explored, and although the estimation of the mean productivity of flowering tillers in crops at varying levels of choke infection may require controlled experiment rather than field survey, as much information as possible on yields from the 1951 crops will be collected during the course of the work in 1952.

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CONTROL OF MILLET SMUT BY SEED DISINFECTION

by W. A. R. DILLON WESTON AND ELIZABETH R. SCHOFIELD

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Common millet (*Panicum miliaceum*) is grown for food grain in Asia and Africa, and, to some extent, for forage in Europe and America. In England, it is said to do well on most types of soil, with a preference for those suitable for barley ; but only a very small acreage is devoted to the crop, and there has been little opportunity in this country for testing seed dressings against the smut diseases of this particular cereal.

An occurrence of Millet Smut at Billing, Northants, in 1944, was probably a new British record (Moore, 1948), and when, in 1949, we received one of six heads showing the same disease in a crop of seven acres of millet at Walton-on-the-Naze, Essex, we took the opportunity of using this head as a source of inoculum for trials in the following year. In the specimen, the entire inflorescence was modified into a sorus enclosed by a greyish-white membrane, which, when ruptured, exposed a dark brown spore mass (Pl. I). The fungus was that formerly known as *Sorosporium panici-miliacei* (Pers.) Takah., and now called *Sphacelotheca destruens* (Schlecht.) Stevenson & Johnson.

Richter and Müller (1943) reviewed the world literature on millet smut when the cultivation of millet as a source of fodder was being revived in Germany during the second world war, and they reported that, in trials made at Berlin Dahlem, they had obtained complete control of the disease by seed treatment with organo-mercurials at the rate of 5 to 7 oz. per cwt. of seed, and almost complete control with 2 to 4 oz. per cwt.

TRIALS AT CAMBRIDGE IN 1950

Our trials included five dry and two wet treatments. A supply of clean millet seed, from Walton-on-the Naze, was contaminated with spores from the smutted head received in 1949. The seed was first damped by keeping it in a saturated atmosphere in an incubator at 28° C. for 5½ hours, and then shaken with the inoculum in a closed glass jar. Portions of the contaminated seed were then treated with three approved organo-mercury seed dressings (A, B, and C), each at the rate of 3 oz. per bushel ; with copper carbonate at 2 oz. per bushel ; and with a seed dressing containing 50 per cent. of tetramethylthiuramdisulphide (D) at 6 oz. per bushel. These five dry treatments were effected by shaking together the dressing and seed in a closed glass jar until all the seeds were evenly covered. For the wet treatments, copper sulphate and formaldehyde were used. With copper sulphate, the seed was just covered with a 2½ per cent. solution and left to steep for 5 minutes, after which it was air-dried and sown within 24 hours. For the formaldehyde treatment, the seed was sprinkled with a solution of 1 part of 40 per cent. formaldehyde in 320 parts of water. The seed was turned constantly during the process, after which it was covered with a piece of cloth soaked in the solution, and left for 4 hours. It was then dried rapidly and sown within 48 hours. Germination tests were made on the seed after all treatments.

A randomized block layout was used for the field trials, with five replications of each of the seven treatments and control (contaminated seed without treatment). Each plot consisted of a single rod row, the spacing between rows

being 12 in. The seed was sown on May 24, 1950, using the same volume of seed for each row, i.e., about one-third of an ounce. The plants in all rows made vigorous and even growth, the yield of seed being about 1 lb. per 80 healthy heads. Counts of total and smutted heads in each row were made during the second week in September.

TABLE 1

RESULTS OF TRIAL OF SEED TREATMENTS FOR THE CONTROL OF MILLET SMUT, CAMBRIDGE, 1950

Treatment	Germination	No. of Heads per Five Rows	
	per cent.	*Total*	*Smutted*
Copper carbonate (2 oz. per bus.)	65	1,571	Nil
Organo-mercury dressing A (3 oz. per bus.) ..	64	2,240	Nil
Organo-mercury dressing B (3 oz. per bus.) ..	65	1,713	1
Organo-mercury dressing C (3 oz. per bus.) ..	71	1,658	Nil
Formaldehyde (1 in 320 of 40 per cent. solution)	74	1,316	13
Copper sulphate (2½ per cent.)	62	1,763	2
Tetramethylthiuramdisulphide (D) (6 oz. per bus.)	73	1,958	11
Contaminated seed (no dressing)	66	1,540	385

Smutted heads, where they occurred, were evenly distributed among the five plots for each treatment, and as the treatment differences were so large, statistical examination of the counts was considered unnecessary. Analysis of the counts for *total* heads showed a critical difference at the 1-in-20 level between treatment totals of 352·5. The total number of heads with treatments A and D was, therefore, significantly greater than in the controls, and in the plots treated with formaldehyde ; but there was no consistent relation between the total number of heads and the percentage germination.

The main results concerning the control of the smut are very clearly shown in Table 1. Apart from a single smutted head in one plot, all the organo-mercury treatments, and copper carbonate, gave complete control. Copper sulphate gave almost complete control, but the formaldehyde and tetramethyl-thiuramdisulphide treatments were less successful, with about 1 per cent. and ½ per cent. of smutted heads respectively, against 25 per cent. of smutted heads in the control.

Chiefly in order to check the relatively poor performance of formaldehyde, trials with this and two other treatments were repeated on observation plots, in 1951. In the single plot of four rod-rows sown with contaminated seed, there was 73 per cent. of smutted heads; in that for the formaldehyde treatment, 17·5 per cent.; and in those for the organo-mercury treatments A and B there were no smutted heads.

We thank Mr. C. C. Brett of the Official Seed Testing Station, Cambridge, for germination tests ; and our assistant, Mr. H. Wheeler, for his care of the plots, and for the photograph.

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THE TORTRIX *CNEPHASIA LONGANA* ON FRUIT TREES IN ESSEX

by H. C. GOUGH

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In June, 1949, some Tortrix caterpillars, found on apple trees at St. Osyth, near Colchester, Essex, were sent to me for identification. The damage, which was confined to the tips of the shoots, did not suggest any of the well-known Tortrix species. We therefore bred out the caterpillars, which at that time were from half- to nearly full-grown. The resulting moths were identified, by Mr. J. D. Bradley of the British Museum, as *Cnephasia longana* (Haworth). According to Meyrick (1928), this species is locally distributed in England south of Yorkshire, as well as throughout west-central and southern Europe and Asia Minor. It has not hitherto been recorded as a pest of fruit trees in this country.

The damage at St. Osyth in 1949 was limited in extent, but in June 1951, a much more serious and widespread attack occurred on the same holding. The caterpillars tunnelled into the tips of the shoots, where they sometimes made an open channel. They also fed on the folded leaves, and those leaves which survived the attack often showed an irregular holing when they opened out. In several acres of young apple trees, chiefly Cox's Orange Pippin and Worcester Pearmain, there were few trees unattacked, and in some, nearly all the shoots were damaged. The damage to leading shoots was of a kind likely to have serious effect on the growth of the trees. Damage was also noted on pears, and on a plantation of blackcurrants, where nearly every shoot on most of the bushes was attacked. Similar damage was seen on thistles nearby, but no larvae were found on these plants. Typical damage was also seen in two or three orchards in the Colchester area, but nowhere was it so extensive as at St. Osyth (Plate IV, 1).

The larvae of *C. longana* are about ½ in. long when full-grown, and pale grey in colour, with two more-or-less distinct pale yellow lines along the back. The head is ochreous, and there is an ochreous plate on the prothorax and the last abdominal segment. The moths, which in the laboratory emerged in July, have a wing span of from ½ in. to ¾ in., and there is a marked difference between the sexes. The forewing of the male is orange-brown and more or less unicolorous, whereas the forewing of the female is pale greyish-yellow and speckled with dark brown markings ; the hindwing in both sexes is paler and unicolorous.

The reported host range of *C. longana* is extensive. The species is recorded by Ford (1949), as feeding on the flowers of *Hypochoeris*, *Anthemis*, *Aster trifolium*, *Chrysanthemum* and *Ranunculus*. In America, Edwards and Mote (1936), recorded it on strawberries, on a wide range of agricultural crops, including wheat, peas, clover, flax and hops, and on roses and blackberries, but not on top fruit. The reported damage has usually been to flowers, seeds or shoots, with typical Tortrix webbing of the parts attacked.

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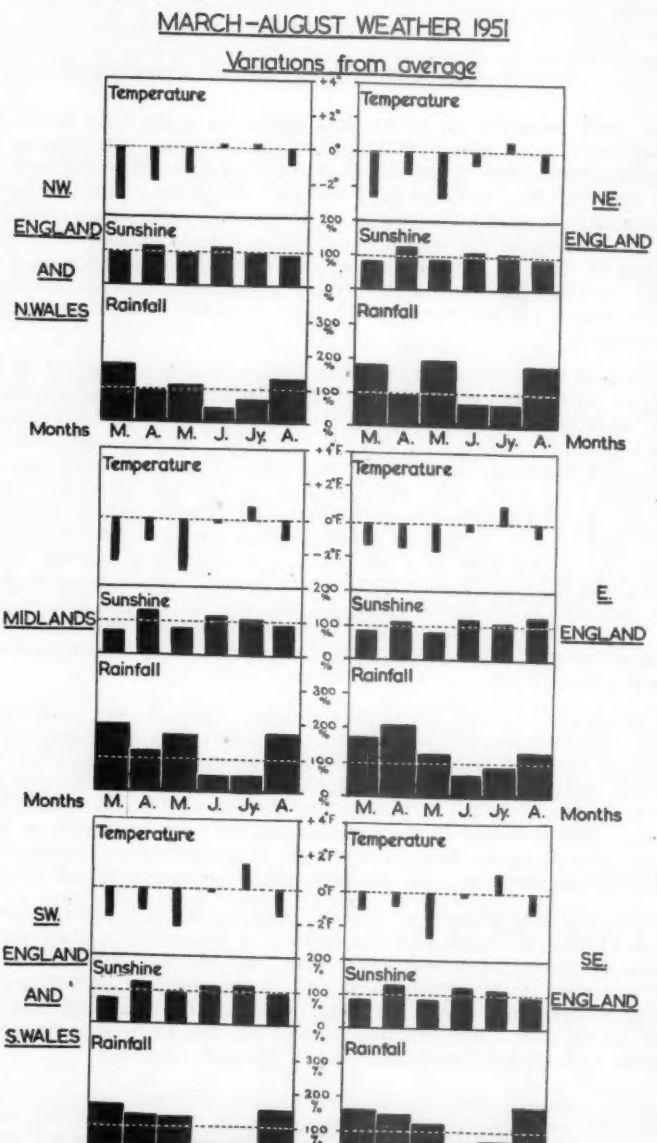
MARCH–AUGUST WEATHER 1951
Variations from average
NW. ENGLAND AND N.WALES
NE. ENGLAND
MIDLANDS
E. ENGLAND
SW. ENGLAND AND S.WALES
SE. ENGLAND
Temperature
Sunshine
Rainfall
Months
M. A. M. J. Jy. A.

THE WEATHER OF ENGLAND AND WALES*

SPRING AND SUMMER, 1951

The spring conditions in 1951 were mainly cold and wet ; the earth temperatures, in particular, were well below normal until the beginning of June. Over England and Wales as a whole, March was the second wettest since 1919, the exception being 1947. The winds were lighter than usual and from a more northerly quarter ; sunshine totals were low. April opened in a similar manner, but the last fortnight of the month was considerably drier, and the period, April 23–25, provided the first mild spell of the year. Cold north-easterly winds prevailed during the first part of May. Snow showers were experienced but there was little or no night frost. Subsequently mild, dull and unsettled weather gave rise to much rain and local thunder ; temperatures reached over 70° F. on the 24th and 25th, but the month in general was cool.

The air temperature was still below average in June, but, in general, the month was sunny and dry with light winds ; the warmest week was the one ending June 16. Similar weather extended into July, but became more unsettled in character. Rainfall was of a thundery nature, and heavy falls were recorded locally. August opened with fine and warm weather, but wet conditions returned at Bank Holiday (6th) and the monthly rainfall totals were high, periods of considerable rain occurring at weekly intervals. In addition, the month was cool, and temperatures were well below average in the week ending August 18.

The weather in each of the six months from March to August (inclusive) is represented graphically on page 32. Figures for six districts in England and Wales are shown in terms of deviation from average for air temperature, sunshine and rainfall. Examination of the previous temperature deviations show that it was the coolest spring and summer for the last 30 years over southern and eastern England, only 1922 and 1941 having comparable conditions.

CEREAL DISEASES IN 1951

The cold, wet weather during early spring retarded the growth of winter cereal crops and considerably delayed spring sowing, so that the harvest was generally about a fortnight later than usual.

Mildew (*Erysiphe graminis* DC.), which usually becomes conspicuous on forward crops in April or May, was exceptionally late and it was not until July, or even August, that it became noticeable, and severe attacks occurred only on a few spring-sown oat and barley crops. Take-all (*Ophiobolus graminis* (Sacc.) Sacc.) was widespread by harvest, but usually caused only occasional scattered whiteheads. Eyespot (*Cercosporella herpotrichoides* Fron) was common in

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* *These notes, and the diagram on page 32, are provided by the Agricultural Branch of the Meteorological Office, and published by permission of the Director.*

eastern districts, but was less prevalent than usual in the north ; it rarely caused serious lodging. These two diseases, Eyespot and Take-all, were often found together in the same crop and were serious only on land overcropped with cereals during the previous few years.

Wheat. The first records of Yellow Rust (*Puccinia glumarum* (Schm.) Erikss. & Henn.) were received in May, and the disease became general in late June or July. In northern districts, it was widely distributed by the end of July, but was not usually serious. The variety Pilot appeared to be worst affected and, in contrast to previous years, crops of Jubilégem were comparatively free. In the west Midlands, most crops were affected to some extent by the end of June, and almost all crops of Jubilégem were particularly severely infected. In eastern districts, the disease became prevalent in July : some severe attacks occurred on Jubilégem, and the variety Nord Desprez appeared to be particularly susceptible.

As in 1950, Black Rust (*Puccinia graminis* Pers.) was common at the end of the season, but infection was probably too late to cause any significant losses. It was first noticed in south-western districts in mid-July, and, by mid-August, was generally distributed throughout the southern half of the country, including mid-Wales.

Loose Smut (*Ustilago tritici* (Pers.) Rostr.) was more prevalent than usual in wheat crops. As in previous years, up to one per cent. was common in crops of Hybrid 46, but from 2–10 per cent. was recorded in the varieties Fylgia, Bersée, Squarehead's Master and Yeoman. Other diseases of wheat, Brown Rust (*Puccinia triticina* Erikss.), Leaf Spot (*Septoria tritici* Rob. & Desm.), Ergot (*Claviceps purpurea* (Fr.) Tul.) and Brown Foot Rot (*Fusarium* spp.), were seen only occasionally.

Barley. Apart from Mildew and Take-all, few diseases were noticed ; slight attacks of Leaf Stripe (*Helminthosporium gramineum* Rabenh.), Leaf Blotch (*Rhynchosporium secalis* (Oudem.) J. J. Davis) and Brown Rust (*Puccinia hordei* Otth) were noted on a few crops.

Oats. Leaf Spot (*Pyrenophora avenae* Ito & Kuribay.) was common in Wales early in the season, and, in some places, caused partial crop failures ; elsewhere it was rare, and the secondary leaf-spot stage was nowhere noticeable. In northern districts, and mid-Wales, the leaf-spot caused by *Septoria avenae* Frank was unusually common, particularly towards the end of the season. In some crops, it was responsible for the death of tillers, and infection of the leaf sheaths sometimes penetrated to the culm at the nodes. Crown Rust (*Puccinia coronata* Corda) and Covered Smut (*Ustilago kolleri* Wille) were both prevalent in mid-Wales. Grey Leaf (Manganese deficiency) was unusually common almost everywhere. The oat strain of Take-all (*Ophiobolus graminis* (Sacc.) Sacc. var. *avenae* E. M. Turner), which is largely restricted to Wales and northern England, was found again in the field in Kent where it was recorded last year for the first time in the south-east.

Rye. Except for a few records of Ergot (*Claviceps purpurea* (Fr.) Tul.), no diseases of rye were reported.

Plant Disease Survey

(51820) Wt. 4068/3410 K.8 3/52 Hw.

SURVEY OF CABBAGE APHID POPULATIONS ON BRUSSELS SPROUTS, 1946-51

Contribution from the Conference of Entomologists, National Agricultural Advisory Service, compiled by D. W. Empson, N.A.A.S., Caversham, Reading, Berks

Although much is known of the life histories and habits of the common insect pests, we have little information about the factors that decide the population level of a species at any particular time and place. Such information might lead eventually to an understanding of the causes of pest outbreaks, and even render it possible to forecast some of them. In writing of the birth of work on insect damage assessment in this country, and of the aims of quantitative pest surveys, Thomas (1948) pointed to the Cabbage aphid (*Brevicoryne brassicae* L.) and the great variation in its populations from year to year—and even from month to month—as an example of the great difficulties facing entomologists trying to forecast insect attacks. Nevertheless, a start was made on this pest, and this contribution is a summary of the work done, year by year, from October 1946, when a standardized counting method was first adopted, until January 1951.

Although slight modifications were made in counting technique as more information became available, the general scheme of work has remained unaltered during the first five years of the survey. In each N.A.A.S. province and sub-province, five or more widely distributed fields of Brussels sprouts were examined in October and five in the following January. In October, each of 25 plants, about equally spaced on a diagonal across each field, was classified into one of four categories, according to the degree of aphid attack. In January, actual counts of live aphids and eggs were made on 10 plants (20 in 1951) in each field. The categories used in the October inspections were :

Clean	No colonies visible on outer leaves or sprouts.
Slight	One or more colonies on outer leaves, sprouts clean.
Moderate ..	One to five sprouts with colonies visible, counting top as one sprout.
Severe	More than five sprouts with visible colonies, and large enough to make them unsaleable.

An index of severity was calculated for each field, using the formula :

$$\text{Index of Severity} = \frac{\%\ \text{Slight} + 2 \times \%\ \text{Moderate} + 3 \times \%\ \text{Severe}}{3}$$

Although no figures were obtained for the number of aphids present on plants in each of the categories, it may be said that one " severe " plant certainly carried far more aphids than 1·5 " moderate " or 3 " slight " ones. An index of severity of 50, for example, indicates very much more than twice the aphid population corresponding to an index figure of 25. The index of severity chosen, however, had the merit that it placed fields in the correct order of intensity of attack, and that, like the logarithmic scale, it gave approximately the same emphasis to small changes in low populations as to large changes in high populations. Table 1 gives the mean index of severity for all the fields examined in each province or sub-province each year. Because of the large sampling and conversion errors, the figures are given to the nearest multiple of five.